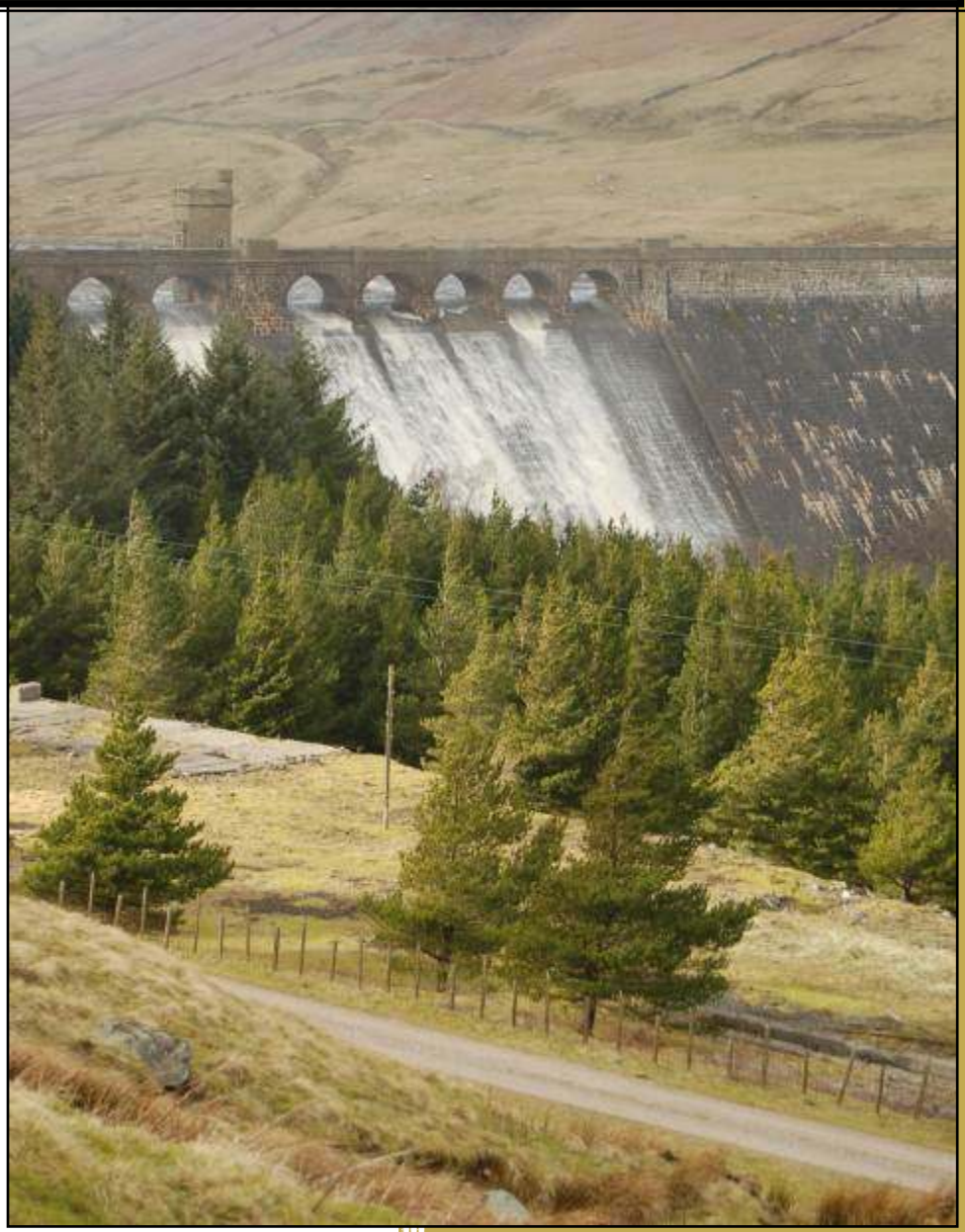
The Hydrology of Goyden Pot and Manchester Hole

Graham Mollard, October 2010



Preface

The Goyden Pot and Manchester Hole systems in Yorkshire are liable to flood and their complex hydrology makes an assessment of whether or not to undertake a trip into either a difficult decision. The purpose of this document is to explain the issues involved, including the changes that have, and will no doubt continue to occur. The document reflects my personal views and experience but I would urge anyone considering leading a trip into these systems to read the whole document carefully.

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The Hydrology of Goyden Pot and Manchester Hole

Manchester Hole and Goyden Pot are somewhat of an enigma. There has been a considerable amount of comment, both written and verbal, for several years relating to the general hydrology of the two systems and in particular to the pattern they both follow in flooding.

One fact cannot be questioned - both fill to the roof in extreme conditions.

Northern Caves Volume One (Brook et al: 1979, p. 19) states that: "Manchester Hole fills to the roof in severe floods when the river flows into the entrance" and Goyden Pot is "liable to complete flooding, particularly if water is flowing into the entrance, or the reservoirs 4.8 kms upstream are full" (Brook et al: 1979, p. 13)

On 14th November 2005 Manchester Hole was the scene of a fatal incident. It is important to understand the short-term hydrological history of both caves prior to this event.

Manchester Hole

- Manchester Hole is fed by two main sinks upstream of the main entrance.
- Other sinks lower down the stream bed towards Goyden come into play when the surface river flows past Manchester's main entrance.
- Even in the driest years, when the upstream sinks are dry, Manchester Hole still has a small underground river flowing. In thirty-seven years the author has never seen the underground mainstream passage dry. Consequently Manchester Hole must be fed via other conduits, probably by autogenic recharge[1].
- There is no evidence that Manchester Hole has any allogenic feeds[2] other than the sinks mentioned above and water entering via the main entrance in catastrophic conditions.
- There was at one time a theory that water from Scar Dam upstream of Manchester Hole could be the source of the continual stream underground. This is disproved in Dr. T.D.Ford's paper 'The Goyden Pot Drainage System, Nidderdale, Yorkshire' (Ford: 1963).
- The upstream sinks have a finite capacity; they could in theory increase if there were a captive hydrostatic head of water above them however

[1] **Autogenic recharge** is when rain or snow falling on limestone areas feed into the cave system via percolation through fine conduits.
[2] **Allogenic recharge** is where water or snow falls on non-permeable rock and then flows into the limestone as a sinking stream e.g. drainage coming off sandstone or shales and then hitting a limestone bed.

water takes the course of least resistance, which in this case is almost certainly the surface river bed.
- There is a possibility of a flood pulse in Manchester Hole when the upstream sinks are not saturated. However once saturation point is reached any possible rise in the water level from that source is negligible.

Prior to 14th November 2005 Manchester Hole was known to flood in three specific ways:

1. **When** Goyden Pot was totally full, water backed up through the Lesser stream passage backfilling Manchester Hole from below.
2. **When** the outflow from Manchester Hole was curtailed by a blockage or partial blockage in the Divers' Chamber or further in to the connection with The Lesser Stream Passage.
3. **When** the surface river was extremely high and flowed directly into the main entrance.

There is another hypothesis that when the Goyden main entrance is taking large volumes of water, this may restrict the slower moving water entering via Lesser Stream Passage allowing it to back up into Manchester Hole. In theory this has some credibility but is at present unproven.

Prior to 14th November 2005 the criteria for planning a trip into Manchester Hole were:

- Is water flowing into Manchester Hole main entrance? If so, don't go.
- Is water flowing into Goyden Pot and, if so, is it full? In these circumstances water could be backing up into Manchester Hole and a trip would probably be unwise.
- What are the weather conditions and is it raining? If so, are the levels in Goyden, if not full, likely to reach a critical level thus affecting Manchester Hole by backfill?
- What are the general ground conditions? Is it saturated resulting in fast run off, or hard baked also resulting in fast run off? Alternatively, is there melting snow, which will also resulting in fast run off if the ground is still frozen? All of these could recharge the Manchester main stream via autogenic drainage.

Importantly there was no evidence that overflow or blown pulses from Scar Dam had any significant effect on Manchester Hole unless some or all of the other factors were also present. Subsequently it was not the norm to check Scar Dam before entering Manchester Hole.

Goyden Pot

- Goyden Pot is fed by Manchester Hole via the Lesser Stream Passage and almost certainly by other unknown conduits probably of an autogenic nature. I do not know of any allogenic feeds other than Manchester Hole and the main entrance of Goyden in wet conditions.
- The water level in the reservoirs upstream of Goyden is critical, as is wind direction.
- If the reservoir is overflowing, either via rainfall or wind-driven pulses, then once Manchester Hole's sinks are at their finite capacity water will continue down the surface stream to enter Goyden main entrance.
- Wind from the west, south west or north west will produce waves which will produce pulses which may overflow the dam arches if the reservoir is full or almost full.
- Height differences from one end of Scar reservoir to the other can be several metres in certain wind conditions.

The criteria for planning a trip into Goyden Pot prior to 14th November 2005 are still the same today:

1. **Consider** the weather over the previous three days, the state of the ground, and the height of the water table.
2. **What** is the wind direction?
3. **What** is the height of the water in Scar reservoir?
4. **What** is the weather forecast for the day?
5. **Is** water flowing into the entrance of Goyden?

All of these should be considered in unison rather than in isolation. The final decision as to whether to enter the cave or not, requires careful consideration of all of them. It is a decision based on judgement built up over many years' experience and training in these environments.

The comments above, both for Manchester Hole and Goyden Pot, were the controls used by professional Cave Instructors prior to the November 2005 incident. They were not followed in a blasé manner as we are all aware of the dynamic nature of the environment and the need to monitor and be aware of change.

The criteria are still completely relevant today for Goyden Pot and cavers / leaders should be in no doubt that to ignore the above would be extremely foolhardy. However with experience of Goyden over many years one can build a clear picture of how it reacts to water. **For cavers and leaders with little experience of the Goyden then it is best avoided if there is more than a trickle entering the main entrance.**

The Changing Picture

The hydrology of Manchester Hole is not static and the following changes both before and after the November 2005 incident are relevant:

1. In January 2005 a fresh sink opened up in the left bank of the surface river just outside Goyden Pot.
2. This appeared to have been enlarged by persons unknown possibly to allow access to the section of cave known as 'Eternal Optimist'. The area close to the entrance of Goyden has been explored and dug for many years.
3. This sink was filled in some months after the November 2005 incident as a result of a serious flood causing boulders, pebbles and general river infill to block this sink
4. In March 2009 this sink appears to have been re-opened by diggers. This new sink has closed again, but this may only be temporary, as digging or serious flooding of the river bed could reopen it at any time in the future.

These facts mean that a new set of criteria may need to be applied to Manchester Hole:

1. When there is a high volume of water flowing into Goyden main entrance, this sink can take some of that water.
2. This water would then normally find its way down into the Lesser Stream Passage and subsequently into Goyden's main stream passage.
3. However in certain circumstances when there is a complete or partial blockage of the hydrological link between Manchester Hole and Goyden Pot, this water can enter the downstream end of Manchester Hole.
4. This coupled with the normal river flow in Manchester Hole can cause catastrophic flooding of the downstream end.
5. The flooding may be extremely short lived, as it almost certainly was on 14th November 2005. When the hydrostatic head of water builds up in the downstream passage it can blow out the blockage resulting in a swift fall in levels. However if the blockage is more robust, the whole of Manchester Hole has the potential to fill to the roof.
6. **All of this can take place when Goyden Pot is not full. This is what occurred on 14th November 2005.**

These problems leave us with the difficulty of establishing some workable criteria when deciding whether or not to run a trip in Manchester Hole. The Heath and Safety Executive (H.S.E) put out some guidelines after the incident, based on a report by Professor John Gunn. These tend to relate mainly to water coming over the arches of Scar House reservoir. I find these criteria overly simplistic and in some cases irrelevant.

Some of the criteria we may use are quite simple:

1. **If Goyden Pot is full then a trip into Manchester Hole should not take place.**

2. **If there is no water flowing into Goyden Pot then a trip into Manchester Hole should be no problem. However, this decision should still be linked to prevailing weather conditions.**

Unfortunately this is where simplicity ends. When water **is** flowing into Goyden Pot, many other factors must be considered. This is where the leader's judgement and experience are of such importance.

Figure 1: Scar Reservoir 28th March 2006
(Photograph by Erica Caswell)

Figure 2: Goyden Pot Entrance (underwater) 28th March 2006 (Photograph by Erica Caswell)

Figure 3: Manchester Hole Entrance 28th March 2006 (Photograph by Erica Caswell)

Figure 4: The River Flowing into Manchester Hole 28th March 2006 (Photograph by Erica Caswell)

Figure 5: Flood Foam in Manchester Hole 28th March 2006 (Photograph by Erica Caswell)

Figures 2, 3, 4 and 5 all show conditions when a trip into Manchester Hole would be unwise.

Figure 6: Scar Reservoir Dam Wall 8th August 2009 (Photograph by author)

Figure 7: Scar Reservoir Dam Wall.

On this day there was no water entering Goyden Pot and the weather was settled. A trip through Manchester Hole via Bax Pot took place. (Photograph by author)

Figure 8: Scar Reservoir 8th May 2008
(Photograph by author)

Figure 9: The Entrance to Goyden Pot 8th May 2008
(Photograph by author)

Figure 10: The Entrance to Manchester Hole in the foreground on the right, taken on 8th May 2008 (Photograph by author)

- On 8th May 2008 as can be seen in figs 8, 9 and 10 a considerable amount of water was coming over the arches of the Reservoir.
- This was caused by both wind-driven pulses and overflow due to the reservoir being full. The new sink was blocked; Goyden was impassable but not full.
- The river is about thigh deep running past Manchester Hole, Manchester Hole levels are normal i.e. ankle deep in the entrance series. In the lower streamway by the fossil crawl levels are at a maximum calf deep, the downstream duck is just passable. Water is flowing uninterrupted through into Goyden.

On 22nd March 2006 Professor John Gunn carried out tests by asking Yorkshire Water to open the scour valves on Scar Reservoir. This was an attempt to replicate the flooding of 14th November 2005. The river bed below Manchester Hole was dry and the Manchester sinks were not saturated, thus allowing a small pulse to show in Manchester Hole. However, overall the release of a major volume of water into the river bed only had an effect upon Goyden Pot.

Figure 11: Goyden Pot entrance before the scour test
(Photograph by Erica Caswell)

Figure 12: Goyden Pot entrance during the scour test
(Photograph by Erica Caswell)

Figure 13: Outside Manchester Hole during the scour test

(Photograph by Erica Caswell)

These photographs serve to highlight the complexity of decisions that have to be made when considering a trip into Manchester Hole post 14th November 2005.

If water is flowing into Goyden Pot, but it is not full then we must consider several factors:

1. How full do we consider Goyden to be?
2. What are the weather conditions and will more rainfall bring Goyden to a critical level?
3. Is the sink open or closed?
4. Is water flowing freely between Manchester Hole and Goyden Pot underground? This can be checked by the leader descending Bax Pot to ensure there is no ponding at Manchester Hole downstream sump.
5. The levels in the reservoir come into play when Goyden has a considerable amount of water flowing into the entrance. Then an increase in the volume of water in the reservoir or blown pulses over the reservoir may bring Goyden into a critical condition.
6. How saturated is the ground, i.e. will any fresh rain or melting snow run off fast?

Conclusions

This document highlights the importance of understanding the hydrology of the Manchester/Goyden system and the many factors that can influence a decision on whether or not to undertake a trip. None of these factors should be taken in isolation but must be seen as a whole. At the end of the day whether to go or not is about judgement and knowledge of the system. Due to the relationship between these factors, the judgement of the professional Instructor cannot be based upon a simple ‘yes’ or ‘no’ consideration of each. The Instructor must apply all their knowledge of the systems he or she uses to ensure they have taken all these factors into consideration in combination.

The circumstances prevailing on 14th November 2005 could not have been foreseen. However, we are now aware of them and the possible effects on Manchester Hole. It is probable that the nature of flooding that day had happened before, but had not been recorded. It is also likely that these circumstances will be replicated in the future. It is therefore the responsibility of all cavers, cave leaders and instructors to err heavily on the side of caution when considering a trip here. Remember caves are dynamic environments and nature itself constantly imposes change on them. Additionally do not forget the changes that cavers can also impose on these systems.

Bibliography

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